Appendix F - Temporal Factor for Mitigation Banking (Derivation)

TEMPORAL FACTOR FOR MITIGATION BANKING (DERIVATION)

Step 1. Recall the formula found immediately after the figure on page 5c-3: T1 = (area of polygon CDBC) divided by (area of polygon CDAC). This formula can be re-expressed as T1 = (the "actual" mitigation stream of benefits) divided by (the "perfect" mitigation stream of benefits).

Step 2. For the following steps, we are going to re-express the functional capacity (FC) in terms of an absolute scale ranging from 0.0 to 1.0. Therefore, the functional capacity of the mitigation site at the time of credit release (C_R) as FC=0.0. Functional capacity starts at zero (FC=0.0) because all of the stream of benefits that are multiplied by T1 are those benefits that are based on the "growth" of functional capacity that occurs after the time of credit release. The maximum predicted capacity is a result of the construction and management activities (C_P) as FC=1.0.

Step 3. To visualize the "perfect" mitigation, at time zero (T_R in the diagram on page 5c-3), start with a one acre parking lot with the functional capacity (FC) of zero (FC=0.0). This is point "d" on the diagram above. Time zero is January 1st of Year 1 of the mitigation polygon. During year 1, the parking lot is removed and planted and reaches maximum capacity (FC=1.0) by the end of year 1. (Editorial note: The formula at the top of 5c-3 refers to a "forested" system but here the mitigation grows in one year! Please accept for purposes of this example these could be exceptionally fast growing trees.) This is point "a" on the diagram. The benefit received in year 1 and every year thereafter until the planning horizon (T_{max}) is 1.0 units per year, for a total of 70 unit-years/acre.

Year	1	2	3	4	5	----	70	Total
a = Unit/acre	1.000	1.000	1.000	1.000	1.000	----	1.000	70.00 Unit-0 years/acre

Step 4. The standard technique is to express these 70 units as an equivalent present worth (PW) number. The PW is based on discounting (reducing) the benefit received in future year. We will use, as described by King et al. (Appendix G), a discount rate of 7.38% per year. The discount formula is PW = (FC in year t) * $(1.0738)^t$. The PW of the "perfect" mitigation stream of benefits is therefore 13.460 PW-unit-years/acre.

Year	1	2	3	4	5	----	70	Total
a = Unit/acre	1.000	1.000	1.000	1.000	1.000	----	1.000	70.000 unit-years/acre
b = Discount	0.931	0.867	0.808	0.752	0.700	----	0.007	
a x b = PW	0.931	0.867	0.808	0.752	0.700	----	0.007	13.460 PW-unit-years/acre

Step 5. Now to calculate the "actual" mitigation stream of benefits. Presume the same parking lot (FC=0.0) that is planted in year 1. This is point "d" on the diagram. However, now the applicant presumes that the plants will take three years to grow to full maturity. This is point "b" on the diagram. Some function will be present and some growth will occur in year 1. The wetland "finishes" growing in year 3 when it reaches FC=1.0. This is point "b" on the diagram. From the table below, the total units per acre received over 70 years is 69.00 unit-years/acre. This is less than the 70 unit-years/acre of the "perfect" mitigation. Applying the discount formula to the stream of benefits results in a PW of 12.547 PW-unit-years/acre compared to the 13.460 PW-unit-years/acre of the theoretically "perfect" mitigation.

Year	1	2	3	4	5	----	70	Total
a = Unit/acre	0.330	0.670	1.000	1.000	1.000	----	1.000	69.000 unit-years/acre
b = Discount	0.931	0.867	0.808	0.752	0.700	----	0.007	
a x b = PW	0.310	0.578	0.808	0.752	0.700	----	0.007	12.547 PW-unit-years/acre

Step 6. The Temporal Factor (T1) is calculated as follows.
T1 = ("actual" mitigation stream of benefits) divided by ("perfect" mitigation stream of benefits).
T1 = (12.547 PW-unit-years/acre) divided by (13.460 PW-unit-years/acre)
T1 = 0.9324

Step 7. As an example, presume the actual mitigation bank is as follows. References are to the diagram above. First, the mitigation site is a parking lot measuring one acre. In the first year the parking lot is removed and planted. T_o = begin construction of the bank = 1 and C_R = functional capacity (FC) at beginning = 0.0. No credits are released in the first year. Second, all of the credits will be released during year two and the functional capacity of the immature wetland is expected to be 0.2 on a scale of 0.0 to 1.0. This is point "d" on the diagram. $C_R = 0.2$ and $T_R = 2$. Note that $T_R = 2$ because the credits are released in Year 2, even though the bank construction started in Year 1 ($T_o = 1$). Third, the plants will continue to grow until reaching full maturity four years after planting. Full maturity is expected to provide a functional capacity of 0.80 on a scale of 0.0 to 1.0. (Note: a FC less than 1.0 will occur because the absolute scale for a region will assign 1.0 to a pristine wetland in an ideal situation whereas the mitigation site may have less than ideal circumstances.) This is point "b" on the diagram. $C_P = 0.8$ and $T_p = 4$. Fourth, the management plan is expected to be implemented that will maintain the full maturity (FC=0.80) for the planning horizon of 70 years. Fifth, the total number of units released during year 2 (T_R), that is the year following the year the construction and planting work was performed, is calculated as follows. Recall that the calculation was presented in the example of the forested mitigation above: Units = $[(C_P - C_{R\text{-forested}}) * T1 * \text{Acres}] + [(C_{R\text{-forested}} - Co) * \text{Acres}_{\text{forested}}]$.

C_R = Units Released in year T_R = [(C_P - C_R) * T1 * Acres] + [(C_R - Co) * Acres].

Substituting the values for the variables (the T1 comes from Step 6 of its derivation above), C_R = Units Released in year 2 = [(0.9 - 0.2) * 0.9324 * 1.0 acre] + [(0.2 - 0.0) * 1.0 acre]. C_R = Units Released in year 2 = [0.5594] + [0.20] = 0.7594

Step 7a. Additional remark on Step 7. The number of units calculated in Step 7 is for a single mitigation polygon. A typical bank consists of several mitigation polygons. The C_R (Units Released in year 2) will be calculated for each of these polygons and the C_R's added together for the grand total of the number of units released in year 2 by the bank.

Step 7b. Additional remark on Step 7. If the banker prefers to release some units in year 2, then some more units in year 4, for example, then some polygons will be identified for year 2 and the remainder identified for year 4. Then the calculation of C_R for each polygon can be made using the appropriate T_R (year of release). The C_R's for year 2 would be added together for the number of units released in year 2 and the C_R's for year 4 would be added together for the number of units released in year 4. The two totals should not be added together for a grand total.

Step 7c. Additional remark on Step 7. The formula presented by King, et al (Appendix G) takes the "future" benefit (that is, that received in a later year) and calculates the smaller "Present Worth" through the use of the discount formula (7.38% per year). However, the formula also takes any "past" benefit (that is, any increase in functional capacity that was achieved in a year prior to the year of the impact occurred) and calculates a <u>larger</u> "Present Worth". One of the fundamental premises of mitigation banking is that credits are available for release after the functional capacity increase has been achieved. Therefore, during the year(s) between the initiation of the construction and management activities of the mitigation bank (T_O) and the Credit Release (T_R), the banking agreement can be written to provide for periodic release of credits equal to the actual (observed) increase in functional capacity. Except for unusual circumstances, the discount formula will not be used to calculate an increase in the number of credits available for release even if the release is "held" or delayed to some year after the actual (observed) functional capacity increase. The purpose of the derivation of the Temporal Lag Factor is to establish a mechanism to provide for a release of credits based on the increases in functional capacity that have not yet occurred (that is, the functional capacity earned after the Credit Release year, T_R).

Step 8. If the nature of the mitigation work warrants, the construction of the bank will be phased and one or more polygons may actually start construction after the date of the release of credits. For example, we will continue the example we left off at Step 7 above, except now the construction and planting will not occur until year 2. Therefore, there is no benefit received during the first year. The Temporal Loss Factor= T1 = ("actual" mitigation stream of benefits) divided by ("perfect" mitigation stream of benefits) = (11.679 PW-unit-years/acre) divided by (13.460 PW-unit-years/acre) = 0.8678

Year	1	2	3	4	5	----	70	Total
a = Unit/acre	0	0.330	0.670	1.000	1.000	----	1.000	68.000 unit-years/acre
b = Discount	0.931	0.867	0.808	0.752	0.700	----	0.007	
a x b = PW	0.000	0.289	0.538	0.752	0.700	----	0.007	11.679 PW-unit-years/acre

Step 9. All the calculations so far use the variable T1 for temporal loss that occurs after the year the credits are released. The project manager must perform a separate calculation for: (1) the credits "earned" prior to the year of the release; and (2) the credits "earned" after the year of release. However, this mathematical burden can be simplified to a single variable for Temporal Lag (T).

From Step 7, the formula is
C_R = Units Released in year $T_R = [(C_P - C_R) * T1 * \text{Acres}] + [(C_R - C_O) * \text{Acres}]$.

King et al. briefly discusses that the increase in mitigation function between construction and maturity can be assumption to be linear, that is, the increase in functional capacity is the same in each year. The increase per year is this total expected increase of functional capacity $(C_P - C_O)$ divided by the total number of years from construction to maturity $(T_P - T_O)$. Therefore, the terms $(C_P - C_R)$ and $(C_R - C_O)$ can be expressed in terms of time.
$(C_P - C_R) = (C_P - C_O) * [\,(T_P - T_R) / (T_P - T_O)]$ where "/" means "divided by"
$(C_R - C_O) = (C_P - C_O) * [\,(T_R - T_O) / (T_P - T_O)]$

Substituting and simplifying:
$C_R = (C_P - C_O) * \text{Acres} * \{\,[\,(T_P - T_R) / (T_P - T_O) * T1\,] + [\,(T_R - T_O) / (T_P - T_O)\,]\,\}$

Substitute the variable T:
$C_R = (C_P - C_O) * \text{Acres} * \{T\}$

Therefore, the Temporal Lag Factor is defined as:
T = Temporal Lag Factor $= [\,(T_P - T_R) / (T_P - T_O) * T1\,] + [\,(T_R - T_O) / (T_P - T_O)\,]$
Simplifying:
T = Temporal Lag Factor $= \{\,[\,(T_P - T_R) * T1\,] + [\,(T_R - T_O)\,]\,\} / (T_P - T_O)$